Fig. 9. Germination of the same, in water, after 44 hrs. Jan. 21, 1893. × 200. Spores taken from volunteer wheat, out doors.

Fig. 10. Spores taken from dead leaves of volunteer wheat, out doors, Feb. 25, 1893. Seem to have germinated on the wheat, and further growth checked by the cold. × 247.

Fig. 11. Germination of uredospores of *Puccinia Caricis* (Schum.). Rebent. in neutralized urine, after 50 hrs. Jan. 1893, × 333. Spores from green-house plant, transplanted from out doors Dec. 1892.

Fig. 12. Germination of uredospores of *Puccinia graminis* Pers. in water, after 72 hrs. Germ tube measures 1.075mm. × 247.

Fig. 13. Germination of *Uredo Cæoma-nitens* Schwein. in water, after 31 hrs. Put in drop culture next day after collection, May 19, 1892. × 333.

Fig. 14. Germination of uredospores of *Puccinia Hieracei* (Schum.) Mart. in water, after 24 hrs. Apr. 30, 1892. × 167.

Fig. 15. Germination of teleutospores of *Puccinia Redfieldiæ* Tracy, in water, after 46 hrs April 29, 1893, collected Oct. 1892. × 247. One mesospore is shown to be germinating.

Fig. 16. Germination of teleutospores of *Puccinia Phragmitis* (Schum.) Körn. in water, after 4 days, April 1893, collected Oct. 1892. × 247.

Fig. 17. Germination of teleutospores of *Uromyces Polygoni* (Pers.) Fuckel. in water, after 46 hrs. April 29, 1893, collected Oct. 1892. × 247.

Fig. 18. Germination of teleutospores of *Uromyces Sporoboli* Ell. & Ev. in water, after 48 hrs. Apr. 17, 1893. × 333.

Fig 19. Germination of teleutospores of *Puccinia Sporoboli* Arth. in water, after 48 hrs. Apr. 17, 1893. *a*, sporidiola. × 247. Only the mesospores germinated, producing catenulate sporidiola.

Fig. 20. Germination of teleutospores of *Puccinia Grindeliæ* Pk. in water, after 20 hrs Apr. 24, 1893, collected Oct. 1892. Producing catenulate sporidiola. *a*. sporidiola. × 247.

Fig. 21. Germination of teleutospores of *Puccinia variolans* Hark.? of *Aplopappus spinulosus*, in water, after 19 hrs., producing catenulate sporidiola. *a*, terminal portions of promycelia, isolated, showing sporidiola in the process of abstricting. *aa*, sporidiola free. × 247.

Botanical notes from Bainbridge, Georgia. I.

AUGUST F. FOERSTE.

WITH PLATE XL.

Rootstocks penetrating the ground vertically.

Every one knows how roots penetrate the ground. The minute terminal rootlets find their way along crevices between the particles forming the earth, and the increasing bulk of the root pushes these particles aside. It is different with a rootstock. Its existence on germination begins near the surface of the ground and if it penetrates the ground vertically it must penetrate it backwards.

Where plants grow in marshy soil, as in the case of *Symplocarpus foetidus*, this is readily understood, but when the ground is more compact it is quite another matter. It must

especially be observed that the older the plant, the deeper the base of the rootstock will penetrate, and the broader it will become as a rule and hence the greater will be the direct resistance to be overcome. In many cases a more or less definite portion of the base of the rootstock dies every year. In that event the remaining portion of the rootstock must pass also through the space left by the decayed part, before it can sink its base to a still lower level.

It is difficult to understand how the broad base of a thick rootstock such as that of *Agave Virginica* L., for instance, or other still more striking instances, penetrate the hard ground. One thing I have noticed is that plants of this description usually have good stout vertical roots from year to year, and that these begin to wrinkle transversely towards the close of the season. Having a very good grip on the ground by means of the minor rootlets, the tension they exert on the rootstocks by their contraction in length must be enormous, but so must also be the resistance of the earth below the rootstocks. The only plausible explanation therefore seems to be, that the base of the rootstocks are able to force a passage slowly, little by little, when the ground is much softened by rains. This is a subject needing more investigation than has hitherto been given to it.

In this connection it was interesting to observe the habits of one of the palmetto palms, *Sabal Adansonii* Guerus. Here the rootstock is not drawn into the soil backwards but quite the reverse process takes place. In fact the initial narrow end of the rootstock is here directed upwards, and the later growth is formed along the rootstock deeper in the soil, so that a considerable part of the rootstock is pointed directly downwards, earthward, increasing in size in the same direction. At the lower thickened end, the tip of the rootstock is however bent abruptly to one side and then up until the tip itself points upwards. Strong roots are attached to the old rootstock and strong roots are also sent out at the just described strong bend below. It is evident that this curved portion straightens itself out at intervals, the roots drawing the successively newer and straightened portions down into the soil. In this way the base of the curved portion of the rootstock behind the tip is sometimes found at a level of considerably more than a foot beneath the level of the soil, from which level the rootstock must have started.

In the oldest plants the straightening out below the tip does not keep pace with the development of the axis about the tip, or its increase in length, so that the tip beyond this curvature is greatly thickened, producing a sort of tuberous rootstock. The general effect of this thickened end is that of the bowl of a short Dutch pipe, of which the older, longer end, tapering towards the initial extremity near the surface of the ground, represents part of the pipe-stem. The rootstocks of this palmetto may therefore be said to grow indirectly downwards into the soil, and they are not hauled down backwards as a whole, as is the case with so many other vertical rootstocks.

Notes on Leguminosae.

1. *Changes in color of flowers.*—The genus *Tephrosia* permits several interesting though not striking remarks on the changes of colors in flowers. *T. spicata* T. & G. has pure white flowers when fresh, turning purple on fading. *T. ambigua* Curtis has white flowers, the veins and the midrib of the keel, except toward the margins, being colored almost russet red. The flowers very soon became tinged light pink or rose, and on fading also turn purple. *T. hispidula* Pursh. is described as having purple flowers. It is evident that the chemical substances giving rise to the purple color are present in all these flowers, but they are differentiated at different times. In the first species this does not take place until the time of fading. In the second it has taken place in the veins when the flower opens, and soon begins in a mild way over the entire surface of the petals. In the last species the differentiation of this purple coloring matter has been completed before the flower blossoms.

It may perhaps also be inferred that this purple coloring matter (stable only under more vigorous conditions of the cells forming the petals) is due to the breaking up of previously existing chemical compounds, owing to a sort of process to disintegration or decay, since the change towards a purple color in the first two species takes place either at the time of fading, or at least is, in the second species, strongly accentuated at that time. The inflorescence consists of peduncled racemes, which are terminal. By the development of branches from the axils of the last leaf, a sympodial growth ensues, which in the case of *T. ambigua* may give rise to a number of

seemingly axillary peduncled racemes, which in reality, however, all terminate as many axes of growth.

2. *Flowers with the lower side turned up.* — Such an one is *Clitoria Mariana* L. The peduncle of the one- to three-flowered raceme is axillary and bears two minute opposite bracts at its base. In typical cases the lower flower pedicel on this raceme is subtended by three bracts of which the lateral ones represent stipules and the central one which is tripartite represents the subtending leaf. At the base of the pedicel are two opposite bracts equal in size to those last mentioned, so that five bracts cluster around its base. At the base of the calyx two similar opposite bracts occur, which structurally decussate with the lower pair, though owing to a twist of the pedicel through ninety degrees the last two pairs of bracts lie in the same plane.

This twist can easily be followed. Without it, the keel of the flower should structurally face laterally; following the general habit of Leguminosæ it should face downward, as a matter of fact however, and largely owing to the twist of the pedicel, it faces upwards and *the flower is thus turned with the lower side up.* The upper flower pedicel has, at its base, one bract to represent the subtending leaf, or a tripartite bract when solitary. Two more bracts, opposite to each other, occur at the base of this pedicel, two more occur as usual at the base of the calyx, and the intermediate pedicel is again twisted. *The tip of the axis of the raceme is aborted* and remains as a minute tip at one side of the base of the last pedicel.

Owing to the long tubular calyx and the broadly spreading habit of the vexillum the flower has a narrowly obovate appearance. The wings equal five-sixths the length of the vexillum, and the last two-fifths of the length is free from the keel, and is large and spreading. The keel is one-third the length of the vexillum. It is composed of two petals which are held together by a ridge near the inner margin of one petal with a deep groove along its outside and a corresponding infolded portion at the inner margin of the other petal, a little mucilaginous substance helping to keep them in place. The wings are free except near the middle of the expanded terminal portion of the side of the keel, where they are strongly pasted to the keel by a mucilaginous substance. The whole thus forms a case for the stamens and pistil, which is closed below (in a struc-

tural sense), and in front, but which above, is open for most of its extent, this portion of the case being held together only by the walls of the tubular calyx. Near the tip, however, the outer sides of the petals of the keel are strongly infolded, overlap, and are pasted together by a mucilaginous substance leaving only the acute tip free, as a passage for the terminal end of the style.

The stamens are diadelphous, the upper stamens being structurally free, though pasted to the inner sides of the lower monadelphous portion formed by the other nine stamens. The base of this tenth stamen is free for one millimeter to permit the escape of the honey formed by the horseshoe shaped gland at the base of the stamens within the tube.

The upper third of the stamen is also entirely free. The tenth stamen is held in position not only by the mucilage, but also by the fact that the sides of the slit tube formed by the remaining stamens are in a state of tension and press upon the tenth stamen, laterally springing back when loosened. The lower side of the flattened style is smooth, the upper side is hairy, as is also the stigma, especially along its upper margin. When visited by bees only the upper portion of the style appears above the tip of the keel, its upper hairy surface pushing out the pollen.

Centrosema Virginiana Benth. is so closely related as to have been described as a *Clitoria* by Willdenow. Its general habits are the same. Two bracts are found at the base of the peduncle and from the axils of these may arise one or two additional peduncles, also with two basal opposite bracts on each. All three peduncles have different times of flowering. At the base of the pedicels are three bracts representing the subtending leaf with its stipules, or an obovate bract with three teeth along the quadrangular apex, representing the same, or a single simple ovate bract, in which all three elements are probably united. The tripartite bracts subtend the lower, the rest the upper pedicels. The *two bracts* which in Clitoria occur at the base of the pedicels, *in Centrosema are united into a single large ovate bract* directly over the bract at the base of the pedicel. At the base of the calyx are two large ovate bracts a little shorter than the teeth of the calyx, and if the next lower bract were divided into two as it should be morphologically, then the bracts at the base of the calyx would decussate with the latter.

The pedicels are again twisted, so that the keel is turned upwards and the vexillum downwards. The calyx tube is 5^{mm} long, and its teeth extend 11^{mm} beyond the tube. The vexillum is large and orbicular. The wings almost equal the keel in size, the latter being about one-half to four-sevenths the length of the standard. The wings are appressed to the sides of the keel, following its curvature, and are pasted to the latter by a mucilaginous substance. The two petals of the keel are grown together along their (structurally) lower, inner sides, and, excepting at the base, also along their upper sides, which do not overlap, but meet along their edges. Perhaps the microscope might show that they were here held together along their thin edge by mucilage, but under an ordinary lens they seem to have actually grown together, though so weakly as to permit of separation with any moderately pointed instrument. At the apex of the keel the petals however remain free for a length of 4 or 5^{mm}, and through this slit both the upper part of the style and the stamens are protruded when the flower is visited by bees. This being the case there is no need of hairs along the flattened style to serve as a pollen brush and these are absent. The stigma however is hairy, the largest hairs being along the upper margin.

The upper stamen is *free* and on dissecting the flower is always found distant from the remaining stamens. The latter, of which there are nine, have their filaments united so as to form a tube, remaining structurally open along the top. Excepting at the very base however, and near the apex, the sides of this slit are pressed together, being under tension, so that there is formed a practically closed tube. The slit can be opened by means of any moderately pointed instrument. Perhaps the sides are a little grown together or held together by some mucilaginous substance. The terminal bud on the axis of the flowering raceme seems never to develop though the evidence is not so good as in *Clitoria*. In both *Clitoria* and *Centrosema* therefore, the pedicels are twisted and the flowers turned with the lower side up, so that the visiting insects, chiefly bees, and certain butterflies, receive the pollen on their backs, instead of on their sides and the lower part of their body, as is the case when ordinary *Leguminosæ* are visited.

There is still another papilionaceous plant which arrives at the same results, but in a different way. This is *Stylosanthes elatior*. It has "flowers of two kinds; one kind perfect

but sterile; the other destitute of calyx, corolla, and stamens, and fertile." The fertile flowers consist therefore solely of the legume; a leaflet with two adnate stipules subtends the same, and a pair of bracts is found at the base. The legume has a lateral position. On examining the perfect flowers, these and their legume are also seen to have a lateral position, so that it is impossible to say whether the fertile flowers always were destitute of other floral envelops and organs or not.

The lateral position of the legume is also the proper position for a pair of leaves belonging to the ovary, *directly* succeeding the bracts. The fertile flowers are the lower ones of the short spike. The sterile ones occupy the higher places.

The corolla is inserted at the summit of the constricted portion of the tube. This tube is erect. The standard is strongly reflexed so as to occupy a horizontal position. The keel rises above its plane, and arches forward over the standard. Any insect visiting this flower will therefore receive the pollen on its upper side.

The wings are attached to the keel by two moderately curved hooks; of these, the posterior one is situated at the base of the expanded portion, and is directed backwards, clasping over the inner edge of the free margins of the petals of the keel; the other is attached just above to the inner side of the wings, and is directed forwards, hooking into a corresponding deep depression at the base of the expanded portion of the keel. The petals of the keel are grown together below; above they are free, except the portion just behind the apex, where the *two inner sides* are applied to each other along a narrow margin, and are pasted together, face to face, or are moderately grown together. From the opening left at the apex of the keel, the tip of the barren style is usually exserted. When visited by insects the anthers are also pushed out, and the pollen is left on their heads. How from this place it reaches the recurved style of the fertile flowers below, except by dropping off, is a mystery. Perhaps the long, bristle like hairs on the subtending leaves and bracts serve as brushes. But even then it may be remarked that at least the earlier legumes seem already fertilized.

3. *Inflorescences.*—In the most complex case the peduncles of *Tephrosia* bear clusters of flowers, subtended by a bract. The next, a lateral pair of bracts, bear each a flower pedicel, without bracts. Immediately above the first bract mentioned

is another bract, in whose axil is a flower, without bracts; the bract belonging to this set, which should be found just in front of the peduncle behind the total inflorescence, is aborted. Next follow two lateral bracts above the first pair, each containing a flower, but in different stages of development. The terminal bud of the flowering axis must be either one of these two buds or be obsolete. The median plane of the flowers is vertical.

In the most complex case, the peduncles of *Lespedeza repens* T. & G., bear three or four alternating bracts, the successive ones more or less on opposite sides of the peduncle. Each of the bracts subtends an axis whose tip is aborted, but at whose base are a pair of lateral bracts, each subtending a flower. Consistent with this the apex of the peduncle is likewise aborted. Each flower pedicel bears a little below the calyx two bracts, and the median plane of the flower is vertical.

In *Rhynchosia tomentosa* T. & G., the inflorescences consist of short racemes in the axils of the upper leaves or tripartite bracts representing the leaves, or they are terminal. Whether the apex of these various racemes is aborted or not is unknown. The pedicels are subtended by bracts, but do not bear any themselves, and the median plane of the flowers is vertical. The ordinary plants bear leaves made up of these leaflets, but in the variety *monophylla* there is only one leaflet, though this shows its compound character by a joint near the upper end of the petiole, bearing the usual two minute scales.

Cassia obtusifolia L. has axillary racemes, of which the apex is aborted, and the members are confined to two opposite bracts near the base, subtending flowering pedicels. The latter, at their base, show each a small bract towards the front, the corresponding bract towards the rear against the stem being aborted, though a trace may sometimes be found in the form of hairy, horizontal lines. The median plane of the flower is vertical. A superposed bud occurs in the axils of many of the leaves, otherwise bearing the flowering axis.

Cassia Chamæcrista L. has axillary racemes, which are adnate, for a short distance above the axils, to the stem. The different flowering pedicels are subtended by bracts, and a little below the calyx are two bracts which, however, are distant from each other.

The above descriptions may suffice to show that the struc-

ture of the inflorescence of the *Leguminosæ* is quite variable. The inflorescences may be axillary, terminal, or pseudo-axillary only, owing to sympodial growth. The peduncles may or may not have a pair of opposite bracts at their base. The pedicels may have two pairs (of which one is then near the calyx), or one pair, or no pair of bracts at all, or two bracts may be grown together so as to form only one. The flowers may be in a lateral or in a vertical plane. The tip not infrequently can be proved to be aborted, which agrees with the general rule that *inflorescences composed of very irregular flowers usually do not develop flowers terminating the main axes*, and when such terminal flowers are developed contrary to the rule, these are not infrequently *regular* in form.

The reason why this should be so can of course be readily understood. In the process of forming irregular flowers out of regular ones, the bees and other insects visited chiefly the lateral ones which already were in a position to invite approach only from one direction. The upper terminal erect ones were then neglected and gradually became aborted.

4. *Casting off of tips of branches.*—Since the appearance of the later article on this subject a large *Mimosa* tree was noticed to have shed all the tips of its leaf branches late in May. The casting off of the tips in leguminous trees is quite normal. Indeed, it would be interesting to learn if there be *any* trees of that order which do form terminal scaly buds. Considering the frequency with which ligneous plants of this order shed their terminal leafy buds it may well be questioned whether the abortion of the terminal bud of the inflorescences of this family be not in large measure due to a general habit, instead of the special one following the above rule, according to which certain plants can be said to have no use for regular flowers, and terminal buds are only too apt to produce these. In this connection it may be of interest to refer to the case of *Apios tuberosa* Moench, described by the writer some years ago, in which the inflorescence, a compound panicle, first sheds the tip of the panicle with the attached racemes, and then sheds the upper flowers of all the remaining racemes, leaving the scars thus produced for extrafloral honey glands.

EXPLANATION OF PLATE XL.

Fig. 1. *Centrosema Virginiana*, Benth. Flower with the lower side turned up as in nature. Fig. 2. Same; side view of the bracts, sepals, wing, and keel. Fig. 3. *Clitoria Mariana* L. Flower with the lower side turned up as in nature.

Fig. 4. Same; side view of subtending bract-like leaf with its sepals, lower and upper bracts, calyx, wing, and a glimpse of the keel. Fig. 5. *Stylosanthes elatior* Swartz. Perfect, but infertile flower, furnishing only the pollen, a side view. Fig. 6. Female flower, consisting only of an ovary; the two bracts shown below. Fig. 7. *Œnothera linearis* Michx. with aberrant forms of petals. Bristol, Florida.

BRIEFER ARTICLES.

Bibliography of American botany.—The following circular has recently been sent to botanists and we desire to aid in giving it the widest publicity. See also editorial comment, p. 467.

"One item recommended by the Committee on Bibliography of the Madison Botanical Congress is an author catalogue of current works on American botany. To secure this Dr. N. L. Britton, editor of the *Bulletin of the Torrey Botanical Club*, kindly offered to change the monthly 'Index to literature relating to American botany' to the form recommended.

"Dr. Britton has experimented with details of form and typography and also, as planned, has experimented in reprinting the titles on regular index cards. He estimates that these cards will number nearly 1000 per year and that if the number of subscribers is sufficient, the series for 1894 can be supplied for five dollars.

"The cards will be of extra heavy linen ledger paper, accurately cut and the titles will be exact reprints of the matter that appears each month in the *Bulletin*, which will enable subscribers to keep the entire series in a single alphabet and to incorporate it with other indexes if they wish.

"This is the first step toward accomplishing the plans recommended by the Committee, and it is hoped that it will meet the approval and support of American botanists.

"Dr. Britton has asked the undersigned to take charge of subscriptions and the monthly distribution of the cards. It is important that we know very soon how many copies will be wanted. If you want it, kindly say so at once. If you can not subscribe now and think you may later, we need to know it. In any case please reply on enclosed postal. Samples inclosed.—CAMBRIDGE BOTANICAL SUPPLY CO., *Cambridge, Mass.*"